Chapter 9 – Combustion Area Sources

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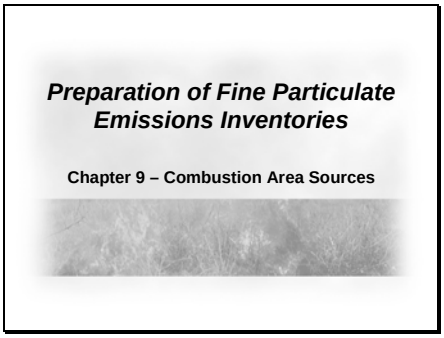

After this lesson, participants will be able to:

- Describe the methodologies for calculating emissions from residential wood combustion, residential and land clearing debris burning, agricultural field burning, and wildland fires.

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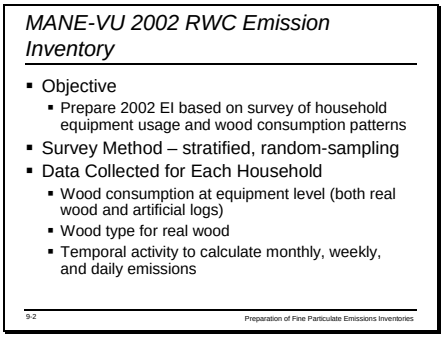

The MANE-VU View Regional Planning Organization conducted a residential wood combustion survey to develop an emissions inventory for the year 2002.

A survey is the EIIP preferred method for this category.

The objective of the MANE-VU project is to prepare a 2002 inventory based on a survey of household equipment usage and wood consumption patterns, using a stratified random sampling approach.

The data collected for each household consists of:

- wood consumption at the equipment level for both real wood and artificial logs;
- the type of real wood; and
- the temporal activity to calculate monthly, weekly, and daily emissions.

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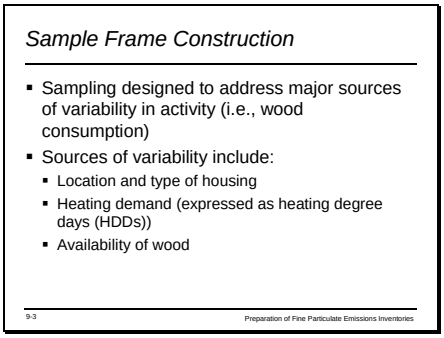

The sampling was designed to address major sources of variability in wood consumption activity.

These sources include:

- the location and type of housing;
- the heating demand expressed as heating degree days; and
- the availability of wood.

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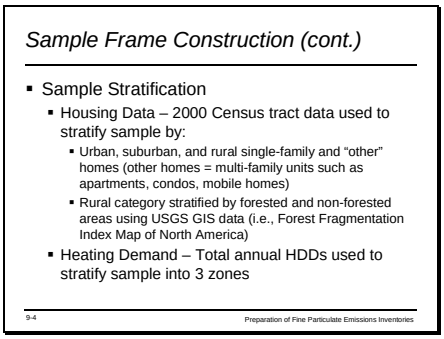

Housing data from the 2000 census covers four categories:

- urban
- Suburban
- rural single family
- stratified into forested versus non-forested areas using USGS-GIS data.
- other homes
- includes multi-family units:
- Apartments
- condominiums
- mobile homes

Total annual heating degree days were used to further stratify the sample into three zones:

- low,
- medium and
- high.

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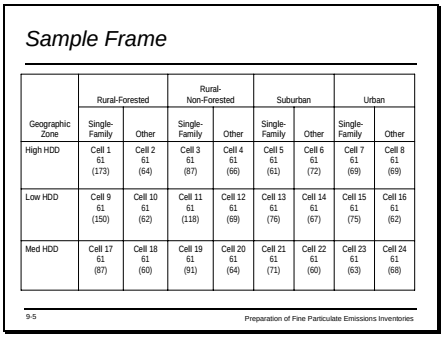

This slide shows a sample frame shown in a grid.

61 is the minimum sample size determined based on calculations for the precision desired from the survey

The numbers in parentheses represent the number of surveys that were actually collected or completed.

Surveys for which the respondents did not categorize correctly were removed from the sample.

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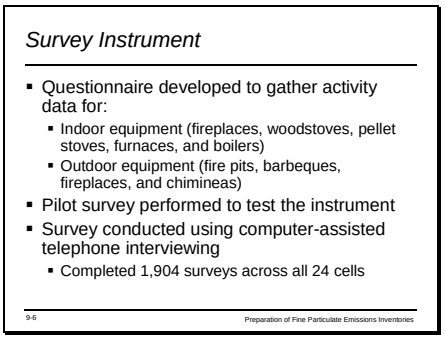


The survey instrument is a questionnaire developed to gather the activity data on indoor equipment and outdoor equipment.

A pilot survey was conducted to test the questionnaire.

Questions were rephrased in order to collect the information that was needed to characterize the activity.

The final survey was conducted using computer-assisted telephone interviewing.

Completed over 1,900 surveys across all 24 cells

9 - 7

Survey Data Reduction/Analysis

- QA reviewed each survey
- Calculated/summarized for each cell:
  - User fraction (fraction of total household population that burns wood in indoor and outdoor equipment)
  - Annual activity (cords of wood by equipment and wood types)
  - Temporal data
- Conducted statistical analyses to identify significant differences between cells for:
  - User fraction
  - Annual Activity

9-7 Preparation of Fine Particulate Emissions Inventories

Surveys were quality assured to make sure that the data collected made sense.

Cell summaries included:

- the user fraction,
- the annual activity, and
- temporal data.

Statistical analyses identified significant differences between cells:

- the user fraction
- annual activity

9 - 8

Indoor Wood-Burning Equipment Preliminary Survey Results (% Burners)

Geographic Zone	Rural-Forested		Rural-Non-Forested		Suburban		Urban	
	Single-Family	Other	Single-Family	Other	Single-Family	Other	Single-Family	Other
High HDD	Cell 1 FP= 34 WS= 67 FB= 21 PS= ***4***	Cell 2 FP= 75 WS= 75 FB= 0 PS= 0	Cell 3 FP= 43 WS= 76 FB= 7 PS= 0	Cell 4 FP= 33 WS= 67 FB= 0 PS= 0	Cell 5 FP= 36 WS= 64 FB= ***18*** PS= 0	Cell 6 FP= 0 WS= 0 FB= 0 PS= 0	Cell 7 FP= 80 WS= 30 FB= 0 PS= 0	Cell 8 FP= 100 WS= 0 FB= ***50*** PS= 0
Low HDD	Cell 9 FP= 60 WS= 65 FB= 5 PS= ***2***	Cell 10 FP= 100 WS= 0 FB= 0 PS= 0	Cell 11 FP= 61 WS= 54 FB= ***4*** PS= 4	Cell 12 FP= 50 WS= 50 FB= 0 PS= 0	Cell 13 FP= 70 WS= 35 FB= 0 PS= 5	Cell 14 FP= 67 WS= 0 FB= 0 PS= 33	Cell 15 FP= 90 WS= 10 FB= 0 PS= 0	Cell 16 FP= 100 WS= 0 FB= 0 PS= ***20***
Med HDD	Cell 17 FP= 55 WS= 66 FB= 7 PS= 7	Cell 18 FP= 60 WS= 60 FB= 0 PS= 0	Cell 19 FP= 59 WS= 45 FB= 0 PS= 9	Cell 20 FP= 100 WS= 0 FB= 0 PS= ***25***	Cell 21 FP= 81 WS= 27 FB= ***8*** PS= 4	Cell 22 FP= 50 WS= 50 FB= 0 PS= 0	Cell 23 FP= 100 WS= 0 FB= 0 PS= 0	Cell 24 FP= 0 WS= 0 FB= 0 PS= 0

FP = fireplace; WS = woodstove; F/B = furnace/boiler; PS = pellet stove; Totals do not always add to 100 since some respondents use more than one type of equipment. Values in ***bold italics*** are derived from responses that were identified as wood consumption outliers (equipment could be miss-categorized by the respondent).

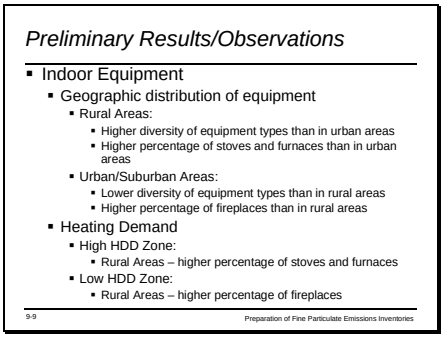
9-8 Preparation of Fine Particulate Emissions Inventories

This table is the same table that was shown on an earlier slide with the exception that the grid cells have the fraction of indoor wood burning equipment on a percentage basis.

Observations:

- In some cases the fractions add up to more than 100% because some houses were using more than one piece of equipment.
- Rural forested areas within a high heating demand zone have a higher diversity of equipment.
- More rural households are using wood burning equipment than the urban areas.

9 - 9



Rural areas have a higher percentage of stoves and furnaces and boilers than urban areas.

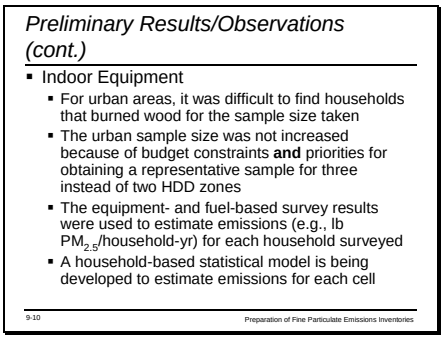
Urban and suburban areas:

- lower diversity of equipment types
- higher percentage of fireplaces

Rural areas:

- higher percentage of stoves and furnaces in the higher HDD zone
- higher percentage of fireplaces in the lower HDD zone

9 - 10



For indoor equipment, because of the sample size of the survey, it was hard to find households that burned wood in urban areas.

Urban sample size was not increased for two reasons:

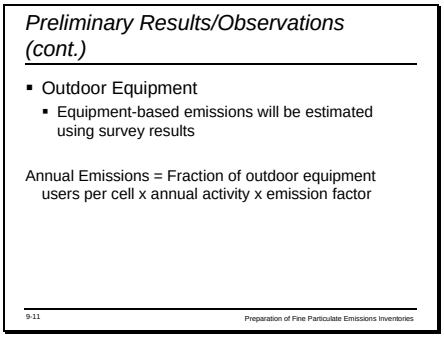
- Budget, and
- Priorities.

As a result, emissions were not calculated for each piece of indoor equipment in urban areas.

Equipment and fuel-based survey results were used to estimate average emissions.

Household-based statistical model was used to estimate emissions for each cell for indoor equipment.

9 - 11



Emissions were estimated for outdoor equipment using the survey results.

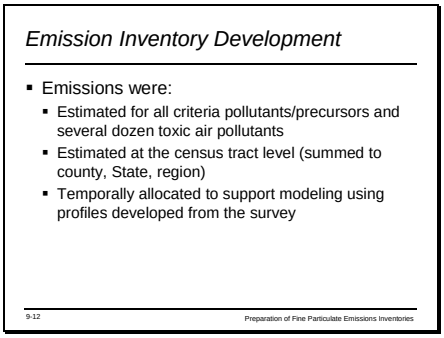
The emissions are the product of:

- the fraction of outdoor equipment users per cell,
- the annual activity, and
- the emission factor.

This is the first attempt to estimate emissions from outdoor wood burning equipment at the household level.

NEI only includes indoor equipment.

9 - 12



Emissions were estimated for:

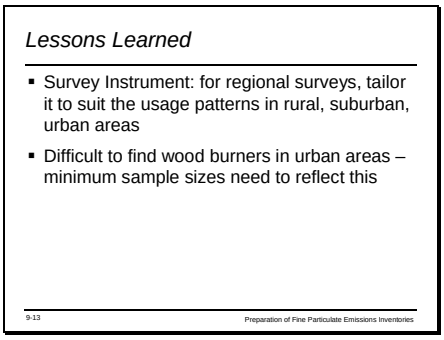
- criteria pollutants and precursors, and
- several dozen toxic air pollutants.

They were estimated at census track level

Summed to the county, state and region.

Emissions were temporally allocated to support modeling using profiles that were developed from the survey.

9 - 13

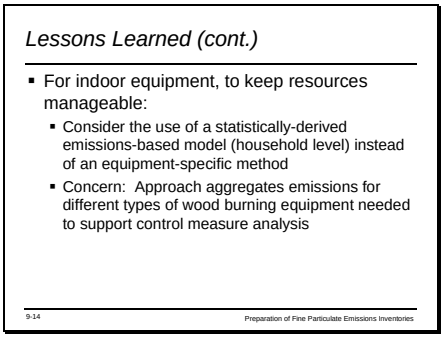


A number of lessons were learned from the MANE-VU study:

Survey instrument for regional surveys should be tailored to suit the usage patterns on rural and suburban and urban areas.

It is difficult to find wood burners in the urban areas, and the sample size may need to be increased to locate these sources.

9 - 14



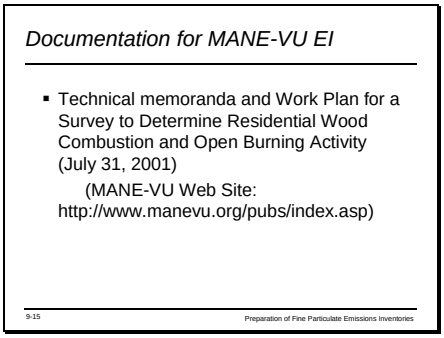
For indoor equipment, keep resources manageable.

Consider the use of statistically derived emissions based model (household level) instead of an equipment specific method.

The concern with this MANE-VU approach is that it aggregates emissions for different types of wood burning equipment.

Should be disaggregated in order to conduct a control strategy analysis.

9 - 15

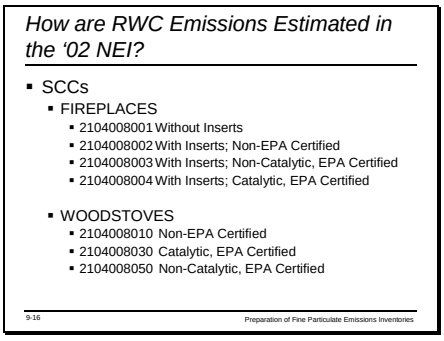


Documentation for the MANE-VU project can be obtained at the web address listed here.

Technical memoranda

Work plan including equations for calculating the sampling precision

9 - 16



NEI categorization:

- Fireplaces - Four SCCs
- Woodstoves - Three SCCs

9 - 17

How are RWC Emissions Estimated in the '02 NEI? (cont.)

- Pollutants
  - PM10-PRI, PM25-PRI, NO_x, CO, VOC, SO_x
  - HAPs (number of pollutants)

9-17 Preparation of Fine Particulate Emissions Inventories

NEI pollutants for residential wood combustion:

- PM_{10} primary
- $PM_{2.5}$ primary
- NO_X
- CO
- SO_X
- HAPs.

The emission factors that are used for residential wood combustion represent primary emissions.

There is no breakout of the filterable and condensable portions of the emission factor.

9 - 18

Emission Factors for Fireplaces Without Inserts (lbs pollutant/ton of dry wood)

- NO_x, SO_x, VOC, & HAPs
  - AP-42, Chapter 1.9, Table 1.9-1
- PM10-PRI, PM25-PRI, & CO
  - Houck, J.E., et al, "Review of Wood Heater and Fireplace Emission Factors," NEI Conference, May 1-3, 2001
  - Based on test data more current than AP-42
  - PM25-PRI assumed to be same as PM10-PRI

9-18 Preparation of Fine Particulate Emissions Inventories

The emission factors for fireplaces without inserts obtained from AP-42 except:

- PM and CO obtained from the reference listed on this slide.
- The $PM_{2.5}$ emission factor assumed to be the same as PM_{10} primary emission factor.

Emission factors for all pollutants from woodstoves and fireplaces without inserts are obtained from AP-42.

9 - 19

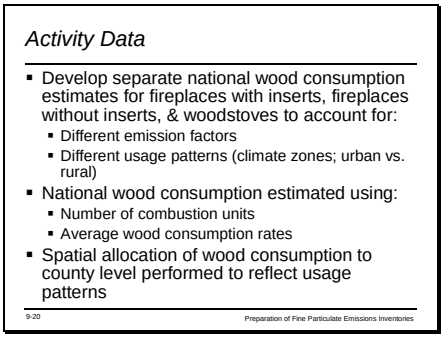
Emission Factors for Woodstoves & Fireplaces With Inserts (lbs pollutant/ton of dry wood)

- Criteria Pollutants: AP-42, Chapter 1.10, Table 1.10-1
  - PM10-PRI, PM25-PRI, & CO EFs are average for all woodstoves
  - PM25-PRI assumed to be same as PM10-PRI
- HAPs: AP-42, Chapter 1.10, Tables 1.10-2, -3, & -4
  - AP-42 EFs for Polycyclic Aromatic Hydrocarbons (PAH) reduced by 62% based on recent test data (Houck, et al, 2001)
- Conversion Factor: One cord of wood equals 1.163 tons

9-19 Preparation of Fine Particulate Emissions Inventories

This slide shows the information for emission factors for woodstoves and fireplaces with inserts.

9 - 20

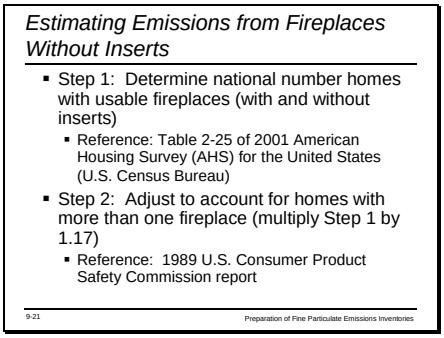


To account for the different emission factors and different usage patterns, the NEI developed separate national wood consumption estimates and emission estimates for:

- fireplaces with inserts,
- fireplaces without inserts,
- and woodstoves.

The methodology is different for fireplaces without inserts than it is for fireplaces with inserts and woodstoves.

9 - 21

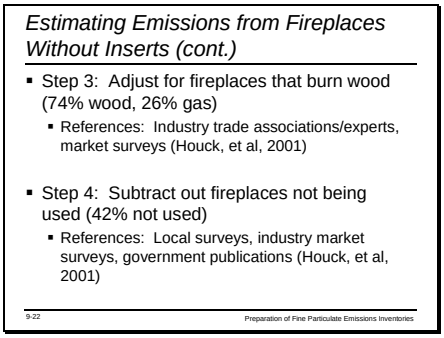


Estimating emissions from fireplaces without inserts

Step 1: determine the number of homes with fireplaces in the United States using data obtained from the US Department of Census.

Step 2: adjust to account for the fact that some homes have more than one fireplace.

9 - 22



Estimating emissions from fireplaces without inserts

Step 3: adjust to account for the fact that not every home burns wood.

Step 4: subtract the number of fireplaces not being used.

9 - 23

Estimating Emissions from Fireplaces Without Inserts (cont.)

- Step 5: Determine number of homes with usable fireplaces with inserts used for heating
  - Used to determine the number of homes with usable fireplaces without inserts
  - Reference: Table 2-4 of 2001 AHS
- Step 6: Adjust to account for homes with more than one fireplace (multiply Step 5 by 1.10)
  - Reference: 1989 U.S. Consumer Product Safety Commission report

9-23 Preparation of Fine Particulate Emissions Inventories

Estimating emissions from fireplaces without inserts

Step 5: subtract number of fireplaces with inserts.

Step 6: adjust for homes with more than one fireplace.

9 - 24

Estimating Emissions from Fireplaces Without Inserts (cont.)

- Step 7: Determine number of fireplaces without inserts used for heating and aesthetic purposes
- The amount of wood burned in each device is determined by assuming wood consumption rates
  - 0.656 cords burned /unit/year for fireplaces used for heating
  - 0.069 cords/unit/year for fireplaces used for aesthetics

9-24 Preparation of Fine Particulate Emissions Inventories

Estimating emissions from fireplaces without inserts

Step 7: Separated fireplaces without inserts into 2 categories: those used for heating and those used for aesthetics.

The amount of wood burned in each device is determined by assuming wood consumption rates:

- 0.656 cords burned /unit/year for fireplaces used for heating and
- 0.069 cords/unit/year for fireplaces used for aesthetics.

9 - 25

Estimating Emissions from Fireplaces Without Inserts (cont.)

- In 1997, EPA estimated that 2.94 million cords of wood were burned in the former and 0.483 million cords of wood were burned in the latter

9-25 Preparation of Fine Particulate Emissions Inventories

In 1997, EPA estimated:

- 2.94 million cords of wood were burned for heating
- 0.483 million cords of wood were burned for aesthetics

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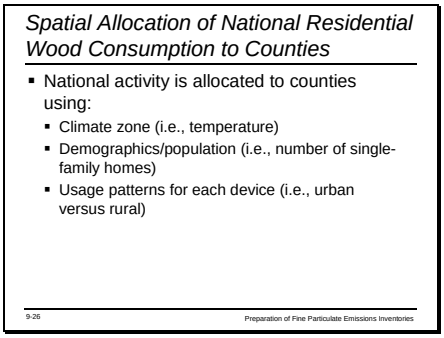
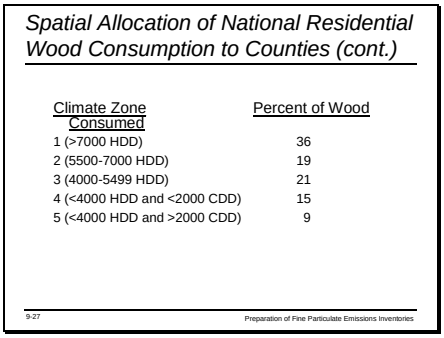


Calculated consumption is allocated to counties based on:

- 1 of 5 climate zones,
- demographics/population, and
- usage patterns.

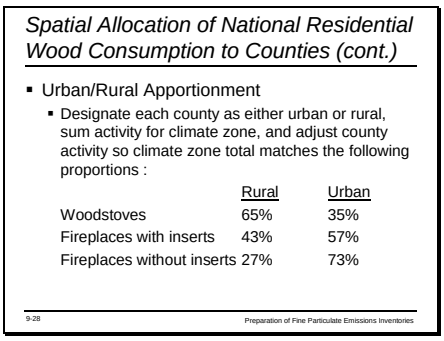
9 - 27



Climate zones defined by:

- ranges of heating degree day and cooling degree day values
- amount of national consumption allocated to each zone

9 - 28



The census data classifies counties as either urban or rural.

Urban = 50 percent of the county's population located in cities and towns

Rural = less than 50 percent of the population located in cities and towns

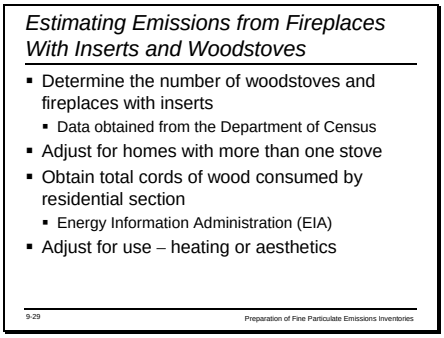
The total wood consumption for all the urban counties are summed for each climate zone, and the same is done for the rural counties.

The data is adjusted if the percentage proportion between urban and rural areas does not match the percentage in the number of units that are reported in the 2001 census.

For example, if the total wood consumption for woodstoves in climate zone 1 is 60 percent for rural and 40 percent for urban, then each urban and rural county within zone 1 receives a percent increase or decrease in cordwood consumption to obtain the correct percent split to reach the 65 percent rural and 35 percent urban split for zone 1.

Finally, AP-42 factors are used to determine county emissions from fireplaces without inserts.

9 - 29



Estimating emissions from fireplaces with inserts and woodstoves

Determine the number of woodstoves and inserts in the United States.

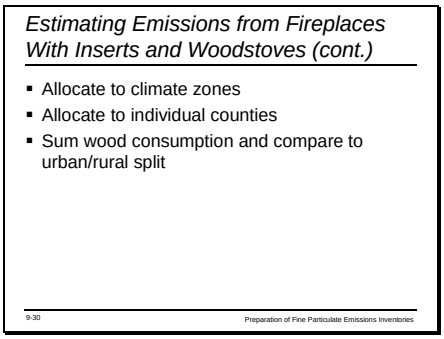
These data are obtained from the DOC. Adjust for the fact that some homes have more than one stove.

The total cords of wood consumed by the residential section for 1997 are obtained from the Energy Information Administration.

Subtract the cords of wood used in fireplaces for aesthetic purposes.

Units used for main heating purposes are considered different from units that are used for other heating purposes.

9 - 30



Allocate consumption to 1 of 5 climate zones.

Within each climate zone, allocate consumption to the individual counties using the relative percent of detached single family homes in the county to the total number of detached single family homes in the entire climate zone.

After allocating to the climate zones, the wood consumption in each zone is summed and compared the urban and rural split.

The total is adjusted until the desired split is achieved.

The split is 65 percent rural and 35 percent urban.

For inserts, the split is 43/57.

9 - 31

Estimating Emissions from Fireplaces With Inserts and Woodstoves (cont.)

- Wood consumption for woodstoves and fireplaces with inserts were apportioned as follows:

Type of Device	Percent of Total Wood Consumption
Non-certified	92
Certified non-catalytic	5.7
Certified catalytic	2.3

9-31 Preparation of Fine Particulate Emissions Inventories

Wood consumption for woodstoves and fireplaces with inserts are allocated to one of the three SCCs.

Fireplaces without inserts are recorded on one SCC.

Once the amount of wood consumed per residential wood combustion type is obtained, AP-42 emission factors are used to calculate emission estimates.

9 - 32

Temporal Allocation of Residential Wood Consumption Emissions

- Default temporal allocation profiles by climate zone
  - S/L/T agencies should adjust allocations to better fit seasonal usage patterns
- Seasonal throughput percentages assigned to each climate zone are:

Climate Zone	Winter	Spring	Summer	Fall
5	100	0	0	0
4	70	15	0	15
3	50	25	0	25
2	40	30	0	30
1	33.33	33.33	0	33.33

9-32 Preparation of Fine Particulate Emissions Inventories

NEI seasonal activity is allocated by climate zone.

The seasonal throughput percentages assigned to each climate zone are listed on this slide.

Zone five is the warmest zone, so all the activity was placed into the winter category.

Summer has no activity with the NEI default method.

The activity is distributed across the seasons for zones two, three and four.

9 - 33

How Can You Improve the NEI for Your Area?

- Preferred Method: Residential Wood Survey
  - Obtain locally representative information on the amount of wood fuel use specifically for woodstoves & fireplaces (with and without inserts)
  - This will require a local survey, or activity data generated by State & local governments
  - Reduces uncertainties in estimates associated with allocating national activity to counties
- Alternative Method: Census Bureau and EIA Data Method
  - Use if resources are limited or emphasis is on preparing summer season inventory

9-33 Preparation of Fine Particulate Emissions Inventories

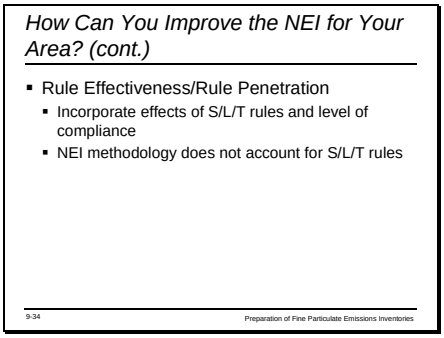
Improving on the NEI method can be accomplished by:

- Conducting a local survey
- Allocating emissions within the seasons.

It is preferable to use local data and the preferred collection method is to do a local or statewide survey.

The EIIP provides an alternative method using census bureau data and the EIA data method.

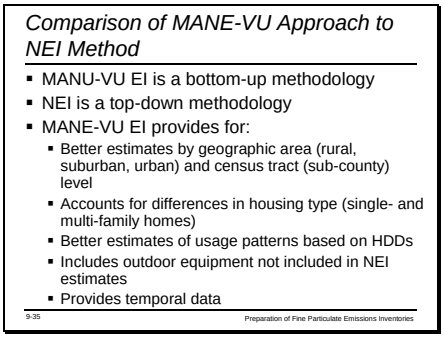
9 - 34



Any assumptions other than 100% for rule effectiveness and rule penetration should be incorporated into the emissions estimation methodology

NEI method does not account for the effect of state and local rules.

9 - 35



The MANE-VU inventory is a bottom-up methodology.

NEI is top down.

MANE-VU:

- Provides better estimates by geographic area and census.
- Accounts for differences in housing type
- Provides better estimates of usage patterns based on heating demand.
- Includes outdoor equipment not included in the NEI estimates.
- Provides some temporal data that can be used to allocate emissions.

NEI emission estimates for residential wood combustion are generally within the ballpark of, but on the low end of the range of, emissions estimated for the MANE-VU inventory.

9-36

Residential Wood Combustion
Case Study - Overview

- Case Study: County level emissions inventory for residential wood combustion
  - See Case Study Number 9-1

9-36 Preparation of Fine Particulate Emissions Inventories

This hypothetical case study involves developing a local inventory using survey data and filling the data gaps with the NEI default data.
Direct student to Case Study 9-1 and discuss it with the students.

9-37

Residential Wood Combustion
Case Study - Solution

- Case Study: County level emissions inventory for residential wood combustion
  - See Handout 9-1

9-37 Preparation of Fine Particulate Emissions Inventories

Distribute the solutions (Handout 9-1) to the case study. Review each question with the students. Encourage discussion among the class. Ask each group to report on the questions that were assigned to them. Ask the other groups to critique their responses.

9 - 38

Residential Open Burning
What Sources are Included?

SCCs:

2610030000 - Residential Municipal Solid Waste (MSW) Burning

Pollutants: PM10, PM2.5, CO, NOx, VOC, SO2, 32 HAPs

2610000100 - Residential Leaf Burning

2610000400 - Residential Brush Burning

Pollutants: PM10, PM 2.5, CO, VOC, 6 HAPs

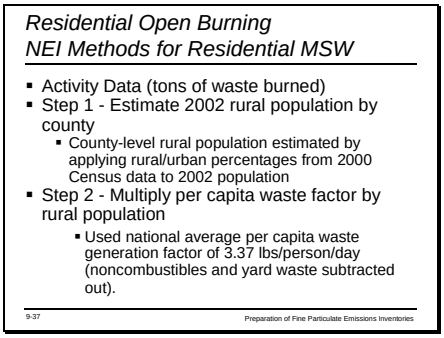
9-36 Preparation of Fine Particulate Emissions Inventories

Residential open burning includes:

- household waste burning
- yard waste burning (includes brush waste and leaf waste).

This slide lists the SCCs and the pollutants for residential open burning that are included in the NEI.

9 - 39

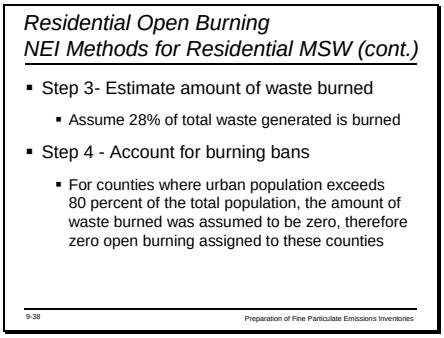


Developing activity data for residential municipal solid waste:

Step 1: estimate the rural population by county by applying percentages of rural and urban population from the census data.

Step 2: multiply the rural population by a per capita household waste factor of 3.37 pounds per person per day.

9 - 40



Developing activity data for residential municipal solid waste:

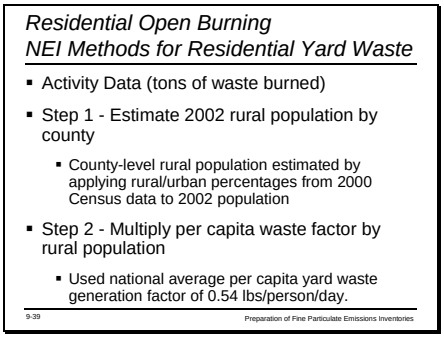
Step 3: estimate the amount of waste burned

Assume that 28% of the household waste generated is burned.

Step 4: account for burning bans.
Ideally this is done by knowing exactly which areas have instituted a burning ban and the time period over which the ban applies.

The NEI assumes that if a county has an urban population that exceeds 80% of the total population the amount of waste burned is zero.

9 - 41

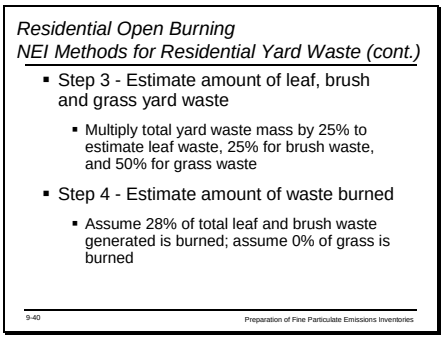


Developing activity data for residential yard waste:

Step 1: estimate the rural population by county by applying percentages of rural and urban population from the census data.

Step 2: multiply the rural population by a per capita household waste factor of 0.54 pounds per person per day.

9 - 42



Developing activity data for residential yard waste:

Step 3: estimate the percentage of total yard waste that corresponds to leaf, brush, and grass waste.

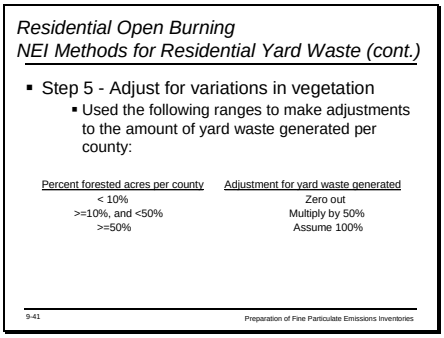
The NEI assumed:
- 25% was leaf waste
- 25% was brush waste
- 50% was grass waste.

Step 4: estimate amount of waste burned.

Assume that 28% of the total leaf and brush waste is burned.

Assume that 0% of the grass waste is burned.

9 - 43



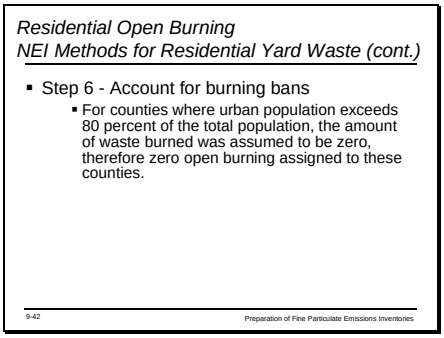
Developing activity data for residential yard waste:

Step 5: adjust to account for the variation in vegetation among the counties.

Use an estimate of the percent of the forested acres per county that was obtained from the biogenic emissions land cover database from the Biogenic Emission Inventory System.

For example, if the BEIS data indicates that a county has less than 10% forested acres, the NEI assumes that there is no yard waste generated.

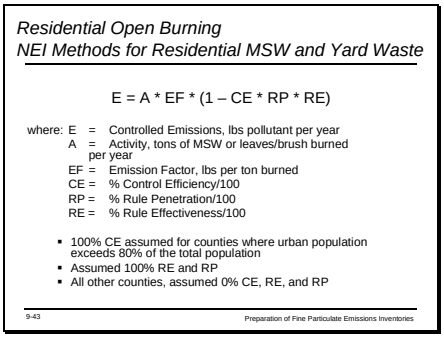
9 - 44



Developing activity data for residential yard waste:

Step 6: account for burning bans in the same manner that was used for household waste.

9 - 45



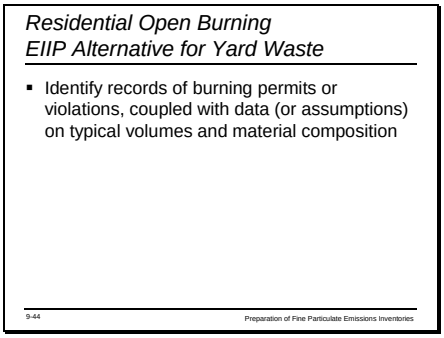
Once the activity data is estimated for both solid waste and yard waste, emissions are calculated by the use of the equation shown here.

A 100% CE is assumed for counties that have an urban population greater than 80% of the total population.

The NEI also assumes that RE and RP are 100% for these areas.

The NEI assumes that all other counties are uncontrolled.

9 - 46

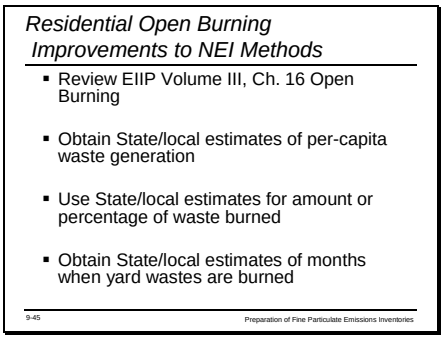


The EIIP document for open burning contains an alternative approach for estimating emissions for yard waste.

This approach involves:

- obtaining records of burning permits or violations, and
- data on typical volumes and material composition.

9 - 47



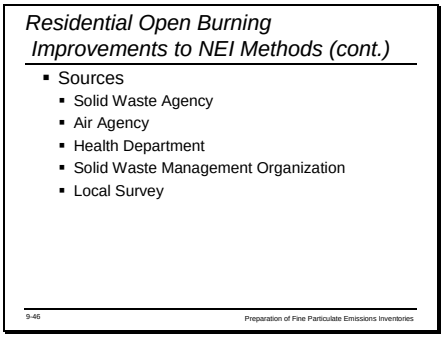
The open burning EIIP contains alternative methods for estimating activity data for this category.

Another approach is to use the NEI methodology coupled with state or local estimates of the per capita waste generation and the amount or percentage of waste burned.

Also, state/local data on the months when yard waste is burned would be an improvement.

The NEI does not make any temporal adjustment for yard waste burning.

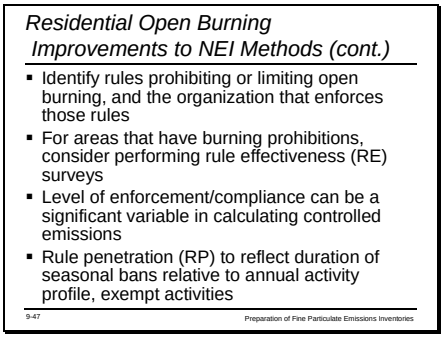
9 - 48



Some of the sources for this type of information include:

- the Solid Waste agency;
- the Air Agency;
- the Health Department;
- the Solid Waste Management agency; and
- the use of local surveys.

9 - 49



The NEI can also be improved by obtaining better estimates of control measures that are applied to open burning.

This involves identifying the rules that limit or prohibit open burning and the organization that enforces those rules (e.g., fire marshal, health department).

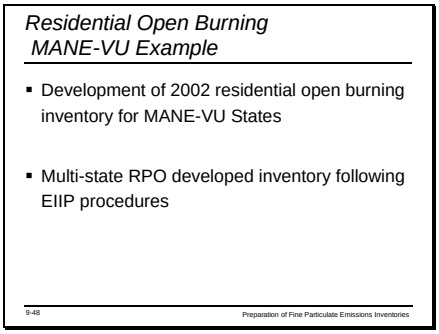
For areas that have burning prohibitions, a rule effectiveness survey can be performed to estimate the compliance rate with the rule.

This is critical in rural areas where there are few complaints about open burning.

Also, rule penetration is critical since many open burning rules have exemptions that are listed (e.g., firefighting training activities, recreational campfires).

Rule penetration is also important for seasonal bans.

9 - 50

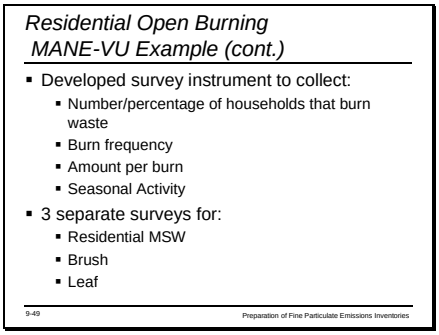


This example examines the development of a 2002 residential open burning inventory for the MANE-VU states.

Developed by a multi-state Regional Planning Organization

Followed the procedures in the EIIP document (i.e., conducting a survey) to obtain activity data

9 - 51



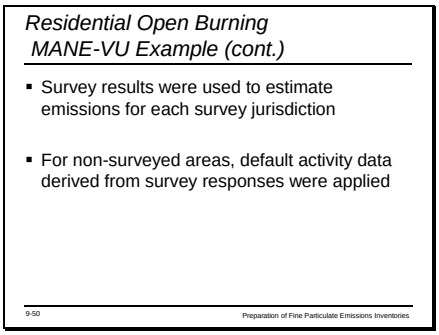
A survey instrument was developed to collect data on:

- the number of households burn waste,
- the burn frequency,
- the amount burned, and
- the seasonal nature of the burning.

Three separate surveys were performed:

- residential municipal solid waste,
- brush waste, and
- leaf waste.

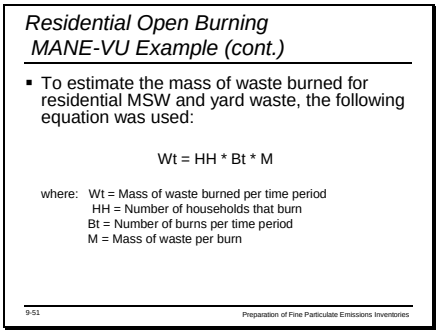
9 - 52



The data collected from these surveys were used to estimate:

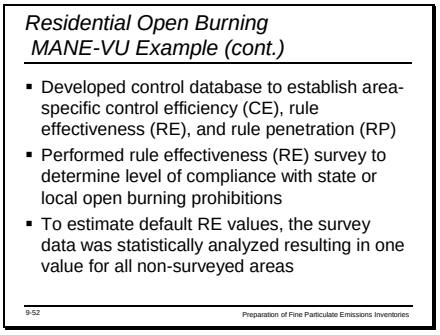
- emissions for each survey area, and
- default activity data for those areas not included in the surveyed areas.

9 - 53



This is the equation that was used to estimate the amount of waste burned based on the data collected from the surveys.

9 - 54



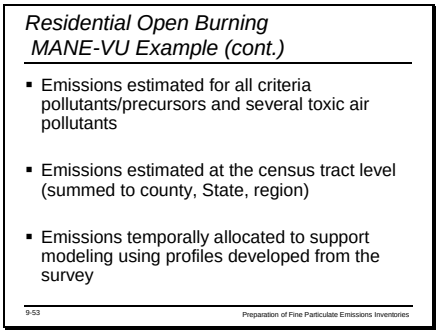
A control database was developed that established area-specific control efficiency, rule effectiveness, and rule penetration.

Rule effectiveness and rule penetration can vary significantly depending on enforcement and the rule applicability.

A rule effectiveness survey was conducted to determine the level of compliance with the state or local open burning prohibitions.

This data was also used to estimate default RE values for use in the non-surveyed areas.

9 - 55



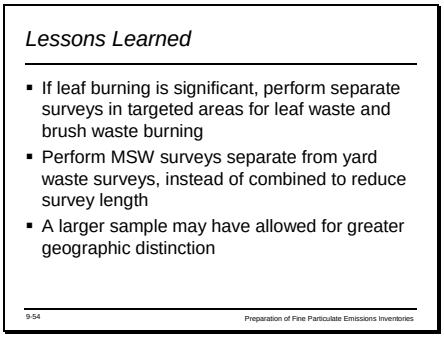
Using the activity data and the control information, emissions were estimated for:

- all criteria pollutants and precursors, and
- several HAPs.

The emissions were estimated at the census track level and summed to the county, state, and regional level.

Finally, the data on the occurrence of the burning activities were used to temporally allocate the emissions to support modeling using profiles that were developed from the survey.

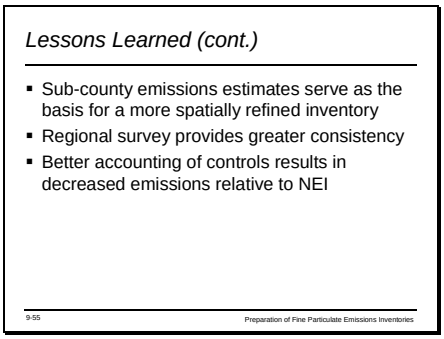
9 - 56



A number of lessons were learned from conducting the survey:

- Separate surveys should be performed in targeted areas where leaf burning is significant.
- Household waste and yard waste surveys should be performed separately simply to reduce the length of the survey.
- A larger sample may have allowed for greater geographic distinction.

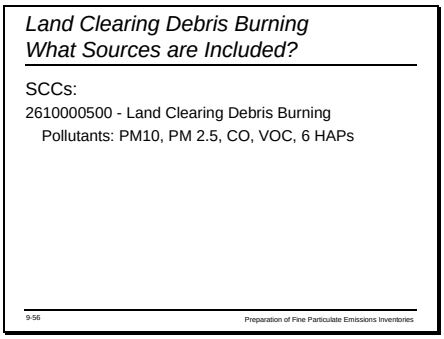
9 - 57



A number of lessons were learned from conducting the survey:

- Sub-county emissions estimates serve as the basis for a more spatially refined inventory.
- A regional survey provides greater consistency that allows for easier comparison of emission estimates from different areas.
- Better accounting of controls results in a decrease of the NEI emissions.

9 - 58



Land clearing debris burning is covered under SCC 2610000500.

The NEI contains emission estimates for PM_{10}, $PM_{2.5}$, CO, VOC, and 6 HAPs from this category.

9 - 59

Land Clearing Debris Burning
NEI Method

- Activity Data
- Estimate the county-level total number of acres disturbed by residential, non-residential and roadway construction
  - Used number of acres disturbed from fugitive dust construction emissions activity calculations
- Apply loading factor to number of acres to estimate the amount of material or fuel subject to burning

9-57 Preparation of Fine Particulate Emissions Inventories

The activity data for this category is the number of acres disturbed for the different types of construction categories.

Step 1: estimate of the county-level total number of acres disturbed.

Step 2: Apply loading factor to the number of acres disturbed to estimate the amount of material burned.

9 - 60

Land Clearing Debris Burning
NEI Method (cont.)

- Weighted, county-specific loading factors developed based on acres of hardwoods, softwoods, and grasses (BELD2 data base in BEIS)
- Multiplied average loading factors by percent contribution of each type of vegetation class to the total county land area

9-58 Preparation of Fine Particulate Emissions Inventories

Step 3: develop weighted county-specific loading factors based on the acres of hardwood, softwoods, and grasses.

Step 4: Multiply average loading factors by the percent contribution of each type of vegetation class to the total county land area.

9 - 61

Land Clearing Debris Burning
NEI Method (cont.)

- Average loading factors for hardwood and softwood further adjusted by 1.5 to account for mass of tree below the surface

Fuel Type	Fuel Loading (tons/acre)
Hardwood	99
Softwood	57
Grass	4.5

9-59 Preparation of Fine Particulate Emissions Inventories

Step 5: adjust average loading factors for hardwood and softwoods by an additional 1.5 to account for the mass of tree below the surface.

The emission factors presented in the table reflect this adjustment.

9 - 62

Land Clearing Debris Burning
NEI Method (cont.)

- Fuel Loading Factor Equation

$$L_w = F_h * L_h + F_s * L_s + F_g * L_g$$

where:
- L_w = County-specific weighted loading factor
- F_h = Fraction of county acres classified as hardwoods
- L_h = Average loading factor for hardwoods
- F_s = Fraction of county acres classified as softwoods
- L_s = Average loading factor for softwoods
- F_g = Fraction of county acres classified as grasses
- L_g = Average loading factor for grasses

9-60 Preparation of Fine Particulate Emissions Inventories

This slide shows the equation for developing the loading factors.

9 - 63

Land Clearing Debris Burning
NEI Method (cont.)

- Emission Calculation

$$E = A * LF * EF$$

where:
- E = Emissions, lbs pollutant per year
- A = No. of acres of land cleared per county (residential + commercial + road construction)
- LF = County-specific loading factor, tons per acre
- EF = Emission factor, lbs pollutant per ton

- Represents an upper-bound emissions estimate
- Assume all fuel loading on land cleared is burned; no controls or bans

9-61 Preparation of Fine Particulate Emissions Inventories

Emissions are estimated from the activity data as shown by this equation.

This formula multiplies:

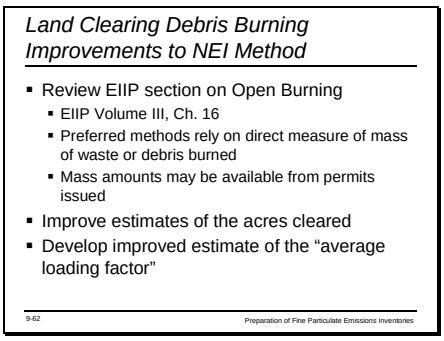
- the activity data,
- the number of acres of land, and
- the county-specific loading factor.

Since the loading factor does not vary by the types of construction, the number of acres cleared for all three types of activities are summed before the loading factor is applied.

The NEI assumes that all the fuel loading on the land cleared is burned and that no controls or bans are in place.

For estimating these emissions, the NEI takes a similar approach as to that used for Residential Yard Waste (see Slide 42), in that it removes emissions from counties that are considered mostly urban.

9 - 64



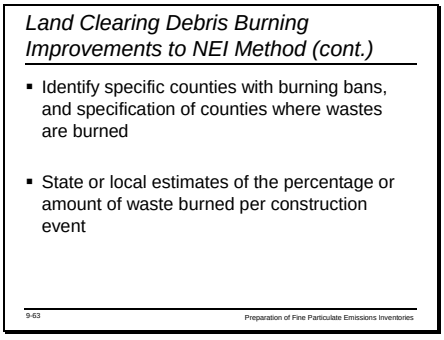
A good place to begin is to Review the EIIP section on open burning.

The EIIP methods rely on a direct measure of mass of waste or debris burned, which may be obtainable from local officials that track this activity for permitting purposes.

Also, obtaining a better estimate of the acres cleared for the fugitive dust construction category would improve the inventory for the land clearing debris burning category.

Other approaches for improving the NEI include developing an improved loading factor.

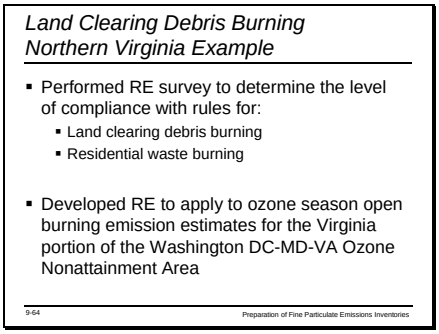
9 - 65



Other ways to improve on the NEI include:

- Identifying specific counties with burning bans and specifying counties where wastes are burned.
- Obtaining state or local estimates of the percentage or amount of waste burned per construction event (The NEI assumes that the fuel loading associated with the land that is cleared is being burned).

9 - 66

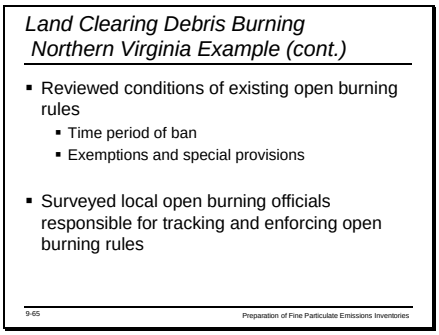


This Northern Virginia area study involved a RE survey to determine the level of compliance with rules for land clearing debris burning and residential waste burning.

The objective of the study was to develop a defensible RE value for use in the State Implementation Plan.

Current EPA guidelines requires the application of an 80% rule effectiveness.

9 - 67

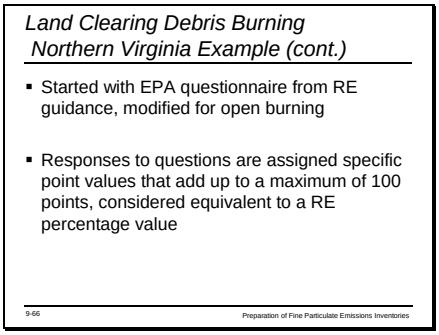


The study reviewed the existing conditions of the open burning rules to determine:

- the time period of the ban, and
- the exemptions that apply.

A survey of local open burning officials responsible for tracking and enforcing open burning rules was conducted.

9 - 68



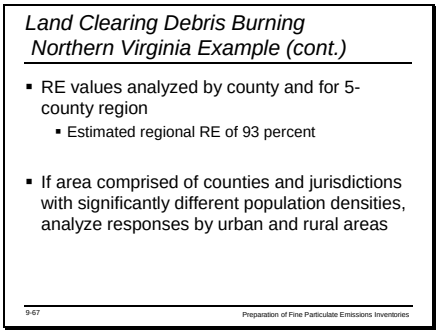
The survey form was derived from an EPA questionnaire that is available from the rule effectiveness guidance.

Responses to the questions on the survey were assigned a specific point value that adds up to a maximum of 100 points.

This point value is considered equivalent to the RE percentage value.

If all the questions were answered with the highest rating, an RE value of 100% was assigned.

9 - 69

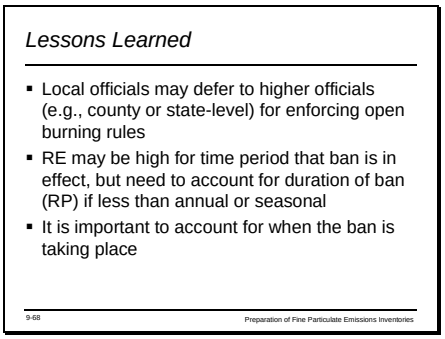


The RE values were analyzed by county as well as for the five-county region.

A regional RE value of 93% was estimated.

Although not done in this case study, separate RE values could be developed for urban and rural area in cases where there are significantly different population densities.

9 - 70



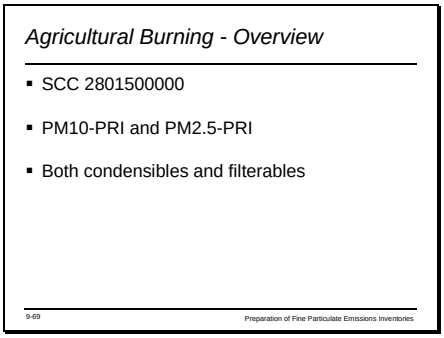
Some of the lessons learned from this study are:

- Local officials tend to defer to the county or state level officials for enforcing the open burning rules.
- In developing an annual emissions inventory, it is important to note that RE may be high only for the time period that the ban is in effect.
- The duration of the ban needs to be taken into account if it is less than annual or seasonal.

Account for when the ban is taking place and if it overlaps with when the activity occurs.

For example, a ban in place for the summer months for brush waste burning will have minimal impact if the majority of the brush burning occurs in the fall.

9 - 71



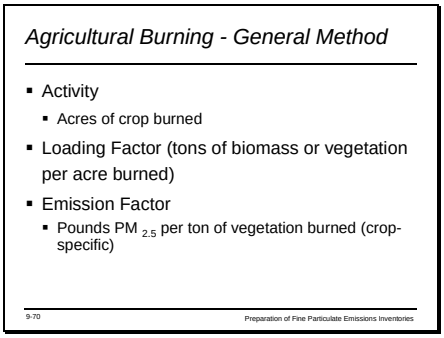
Agricultural burns create particulate matter pollution and their inventory is important to the overall particulate matter air quality analysis.

The SCC for agricultural burning is 2801500000.

EPA encourages States to inventory both PM10 and PM2.5-PRI.

Since agricultural burning is a combustion process, both condensibles and filterables are included in the PM-PRI estimate.

9 - 72



EPA develops emission estimates for most source categories in the NEI and States submit any improved information that they have for those particular categories.

EPA does not at this time prepare an estimate of emissions from agricultural burning.

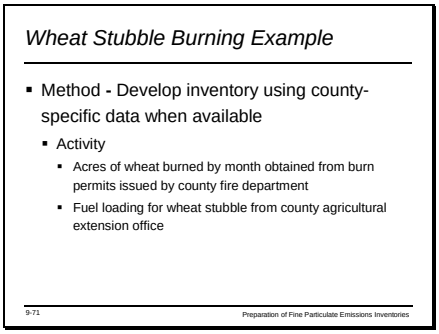
EPA encourages each State to develop their own inventories and submit them.

In 1999 ten States (Alabama, California, Delaware, Georgia, Idaho, Kansas, Maine, Oregon, Texas, and Utah) developed their own agricultural burning inventory.

In general, these States developed the inventories by:

- characterizing the activity or acres of the crop burned,
- the loading factor, and
- the emission factor.

9 - 73



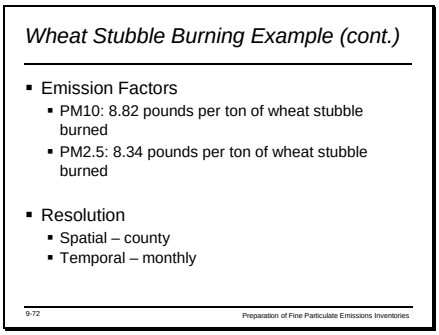
This study involves wheat stubble burning and uses county-specific data.

The activity data that was obtained are the acres of wheat burned by month.

This was obtained from burn permits that are usually issued by the county fire department.

The fuel loading for wheat stubble was obtained from the county agricultural extension office.

9 - 74



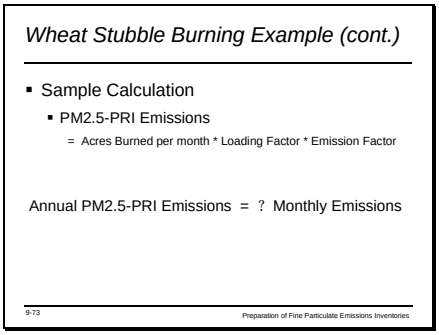
The emission factors are from a study done by CARB

(Jenkins, B.M. et al., *Atmospheric Pollutant Emission Factors from Open Burning of Agricultural and Forest Biomass by Wind Tunnel Simulations*, Volume 2, Results, Cereal Crop Residues, California Air Resources Board Project Number A932-126).

The spatial resolution = county

The temporal resolution = monthly.

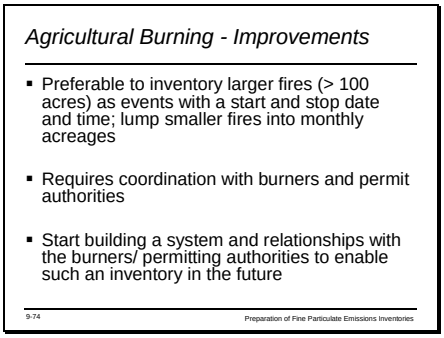
9 - 75



This slide shows the formula for calculating PM2.5-PRI emissions.

This calculation would be repeated for each month during the burning season and summed to give an annual emissions estimate.

9 - 76



EPA encourages all states to develop their own agricultural burning inventory.

For fires larger than 100 acres, EPA suggests:

- locate at a specific latitude and longitude, and
- record stop and start date and time of the fire.

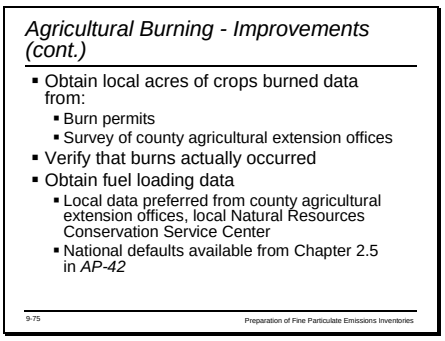
Smaller fires should be lumped into overall monthly acreage like in the previous case study example.

Obtaining information on agricultural burning requires coordination with the burners and the permitting authorities.

In order to develop an agricultural burning inventory, states needs to build a system and a relationship with the burners and permitting authorities.

Chances are pretty good that the first time a State tries to obtain this information they will find that records are not kept or are not kept in a way that can easily be understood.

9 - 77



The local acres of crops burned are obtained from:

- burn permits,
- a survey of county agricultural extension offices, or
- a combination of both.

It is important that States verify that the burns actually occurred.

Often a burner will get a permit to burn a lot more acreage than they actually are able to burn in a particular day.

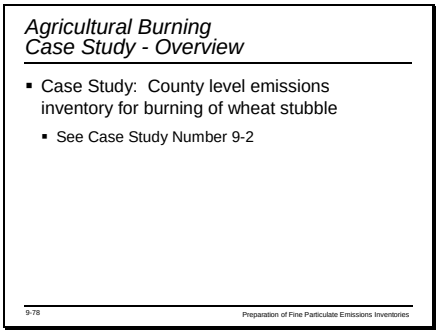
In many cases a burner is limited by the weather or other factors that keep them from burning the acreage that they are permitted to burn.

States need to obtain local fuel loading data.

Obtainable from the local county agricultural extension office or the local Natural Resources Conservation Service Center.

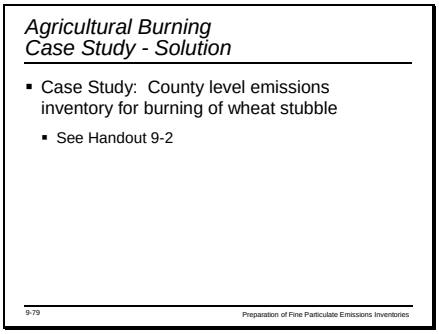
Preferable to using the national defaults that are available in Chapter 2.5 of AP-42.

9-78



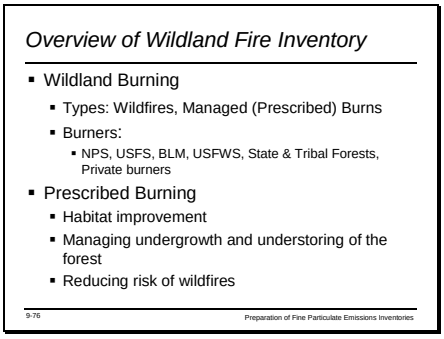
This hypothetical case study involves developing a local inventory using survey data and filling the data gaps with the NEI default data.
Direct student to Case Study 9-2 and discuss it with the students.

9-79



Distribute the solutions (Handout 9-2) to the case study. Review each question with the students. Encourage discussion among the class. Ask each group to report on the questions that were assigned to them. Ask the other groups to critique their responses.

9 - 80



Fires have become a major issue in:

- visibility impairment
- creation of high concentrations of $PM_{2.5}$ that could result in health problems.

The problems have been mainly in the West, but also wildfires from the Southeast, the Central States, Canada, and Mexico have become a concern.

EPA's wildland burning inventory includes both wild and managed burns.

The typical agencies that burn are:

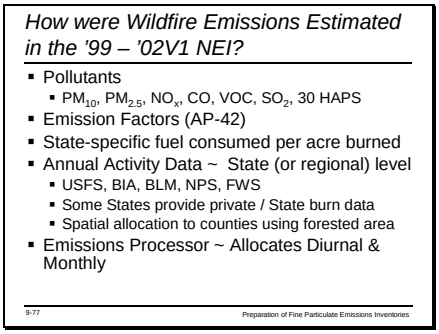
- the National Park Service,
- the United States Forest Service,

- the Bureau of Land Management,
- the United States Fish and Wildlife Service,
- State & Tribal Forests, and
- private burners.

Prescribed burns are those burns that are ignited intentionally:

- for habitat improvement of the wildlife;
- for managing the overall under growth and understoring of the forest; and
- to reduce the risk of wildfires later on by removing the fuels from the forested area.

9 - 81



The approach used to estimate wildfire emissions in the NEI is a very rudimentary approach.

It should be noted that this discussion focuses on the technique for estimating emissions from wildfires; however, emissions from prescribed or managed fires are estimated in a similar fashion.

The pollutants that are included in the NEI inventory for wildland fire emissions are:

- PM_{10},
- $PM_{2.5}$,
- NOx,
- CO,
- VOC,
- SO_2, and
- about 30 HAPS.

The emissions factors for estimating fire emissions and the state-specific fuel consumed per acre burned are found in the NEI documentation.

The technique is to merge the factor and fuel consumption information with annual activity data obtained at either the state or regional level from the main burning agencies.

Most of the federal burners keep fairly good records of the burns that they conduct mostly because these fires end up being watched and/or fought by personnel.

Some states also provide burn data as do some private burners

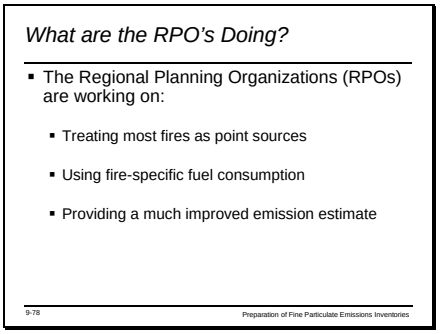
The data obtained from the burners is at the state level or regional level and it is allocated to the state or county level using the amount of forested area in a state.

The amount of acreage that was burned during a year in a particular state is allocated across the state to the forested lands

The NEI allocates the emissions annually and the emissions processor allocates the emissions diurnally and monthly.

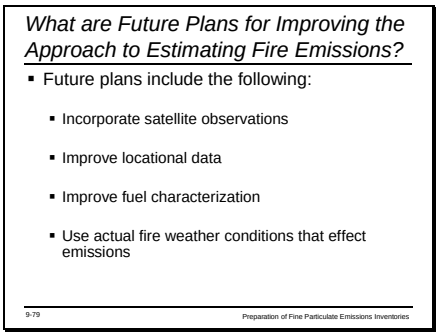
This allocation is important because certain areas of the country have different fire seasons and fire seasons are different for prescribed burns and managed burns.

9-82



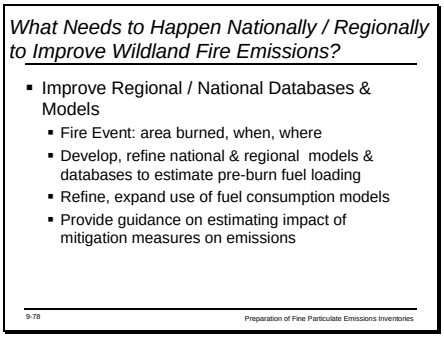
RPOs are working on treating most fires as point sources, using fire-specific fuel consumption, and providing a much improved emission estimate.

9-83



Future plans include incorporating satellite observations, improving locational data, improving fuel characterization, and using actual fire weather conditions that effect emissions.

9 – 84



In order to improve wild land fire emissions, national and regional databases and models must be improved.

Fires need to be treated as events.

Large fires need to be entered into the databases as point sources, including:

- particular location,
- start date,
- end date, and
- the time of day.

National regional models and databases need to be developed and refined to improve the pre-burn fuel loading information.

The information in AP-42 is very general, very dated, and averaged over large regions of the country.

Use of fuel consumption models needs to be to refined and expanded.

Guidance on estimating the impact of mitigation measures on emissions needs to be provided.

9 – 85

Fire Events Database Development

There is a Memorandum of Understanding in effect between the EPA, Department of Interior, and the United States Department of Agriculture to develop a fire events database.

It is a broad scope MOU that covers fire management activities including ways to improve the national databases.

There is a similar effort called nice guy, being conducted at Washington University in St. Louis.

There currently exists a database for recording fire events in the Pacific NW called the B-RAINS system.

Although these types of projects are moving toward real time data collection, quality assurance and data sharing, there is much more work needed in these areas.

9 – 86

EPA is also investigating the potential use of satellites to improve wildland fire inventories.

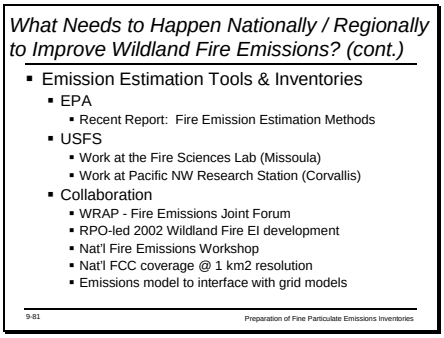
EPA has funded a report entitled *Overview of Using Satellites in AQ Management*.

There is also collaboration going on with NASA to take advantage of their skills in aerial surveillance with satellites.

There are several interagency groups working on the use of satellites including the National Interagency Fire Center (a jointly funded effort of all the Federal burners) in Boise, Idaho, the Missoula Fire Research Center, and Salt Lake City.

Another project includes CAMFER, which is a project underway at University of California Berkeley.

9 - 87



EPA recently published a report entitled *Fire Emission Estimation Methods* that is available on the CHIEF web site that contains a lot of good background information on wildland fire emission estimation.

In addition, there is a lot of ongoing work to improve emission estimation tools for wildland fires.

The US Forest Service has ongoing work on the development of fuel consumption and fire behavior models at the Fire Sciences Lab in Missoula and also at the Pacific NW Research Station in Corvallis.

Also, there is also a lot of emission factor testing occurring in the Fire Sciences Lab in Missoula.

There is also collaboration going on between all the different burn agencies, EPA, and the Regional Planning Organizations.

The Western Regional Air Partnership conducts a fire emissions joint forum and EPA and the burn agencies participate in that forum.

There is a RPO project to refine the 2002 wildland fire emissions inventory.

There was a national fire emissions workshop held in May of 2004 that focused on the latest ideas and methodologies for estimating fire emissions.

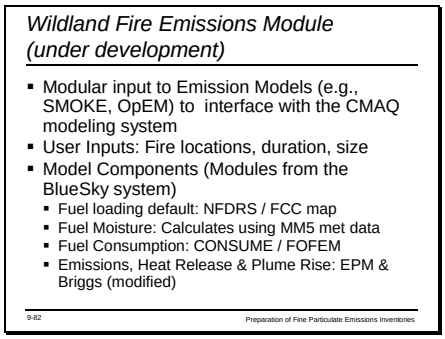
Also, the US Forest Service with assistance and funding from EPA is developing a geographic coverage of the fuel types and fuel conditions for burning at a 1km resolution.

A map of the country that will be useful in GIS systems will be developed out of this project.

Finally there will be further work on developing an emissions model that will estimate fire emissions in real time using real time meteorological data.

Output from this model will be fed directly into the grid models for estimating ambient air concentrations associated with fire emissions.

9 - 88



The emissions model that is under development is the Wildlands Fire Emissions Model.

It will interface with SMOKE and OpEMs, and the CMAQ modeling system.

The user will need to input:

- fire locations,
- durations, and
- size of the fire.

The model components, which will be drawn from the Blue Sky system being developed in the Pacific NW, are:

1) A fuel loading default that will use either the national fire danger rating system or, as it becomes available, the FCC map.
2) Fuel moisture will be calculated using actual metrological data for the period during, and immediately before the fire.

This is a significant improvement over the past and an important improvement since fuel moisture is critical in determining the amount of fuel that will burn and the emissions from that fuel.

3) Fuel consumption models are being built into the model.

Both the CONSUME / FOFEM are such models that have recently been improved significantly.

The CONSUME model is developed in the Corvallis lab and the FOFEM has been developed by the Missoula Fire Lab.

These models compliment each other and have strengths and weakness that, when used together properly, give a pretty good handle on fuel consumption.

4) The emission heat release and plume rise is being handled through the EPM model and the modified Briggs plume rise equation.

There is an improvement to the EPM model called FAR, which is about to be released in beta test form.

9 – 89

Wildland Fire Emissions Module (under development) (cont.)

- Outputs: Gridded hourly emissions, plume characteristics
- Integrate, Test & Release Module (late 2004)

9-83 Preparation of Fine Particulate Emissions Inventories

The output of the model will be:

- a gridded hourly emission estimate, and
- plume characteristics.

The output will be able to be interfaced with grid models to provide a regional scale estimate of the effects of fires.

For instance, this new wildland fire model will be able to estimate the NOx plume from a wildland fire and the effects of that increased NOx on ozone formation.

The integration, testing, and release of the model are anticipated for late 2004.

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